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### (54) WATER DISPERSIBLE BLOCKED ISOCYANATES

WASSERDISPERGIERBARE BLOCKIERTE ISOCYANATE

POLYISOCYANATES BLOQUES CAPABLES DE SE DISPERSER DANS L'EAU

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## Description

[0001] The present invention relates to water dispersible blocked polyisocyanates, methods for making them, water-based storage stable materials, and coatings containing them.

[0002] Blocked polyisocyanates are commonly used in coatings, such as paints, which also contain active hydrogen containing compounds e.g. amines and alcohols. These coatings are deposited onto the article to be coated and then subsequently hardened by heating, often referred to as stoving. During stoving the blocked polyisocyanates dissociate so that the isocyanate groups become available to react with the active hydrogen containing compounds. This leads to crosslinking and hardening of the coating.

[0003] A blocked polyisocyanate coating composition ideally has two properties: (a) a dissociation temperature low enough to allow hardening without heating to temperatures which degrade the coated item and (b) water dispersibility so that the use of organic solvents can be kept to a minimum or eliminated. However, generally a blocked polyisocyanate having a low dissociation temperature will be highly reactive and thus will be inherently unstable in water so that the two properties are incompatible.

[0004] Various means for increasing water dispersibility have been described.

[0005] US 4,522,851 describes a water-dispersible blocked isocyanate in which a hydrophilic group such as an anionic group is chemically incorporated into the polyisocyanate component to make the blocked polyisocyanate water-dispersible. US-A-4,507,427 describes aqueous blocked polyisocyanate solutions or dispersions produced by mixing the blocked polyisocyanate with water in the presence of enough base to guarantee the solubility or dispersibility of the polyisocyanates. US 4,098,933 describes water-dispersible blocked polyisocyanates in which the blocking groups contain a hydrophilic group such as a carboxylic acid salt or polyethylene oxide units.

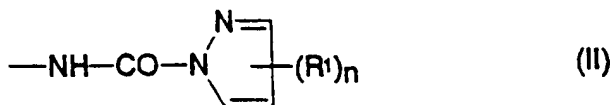
[0006] Most conventional blocked polyisocyanates dissociate at temperatures of around 160°C. EP-A-0159117 discloses pyrazole blocked polyisocyanates which dissociate at a temperature significantly lower than this. Since the pyrazole blocked polyisocyanates are more reactive than conventional blocked isocyanates, they are inherently less stable.

[0007] The present inventors have now established that, despite their high reactivity, certain pyrazole blocked polyisocyanates can be used in aqueous dispersion coating compositions and that the compositions have good storage stability. Accordingly the present invention provides a water dispersible blocked polyisocyanate of the formula (I)



where R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and comprising at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid,

and each group Y, which may be the same or different, is a group of formula (II)



where R<sup>1</sup> is in alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl, NO<sub>2</sub>, halogen or a group -C(O)-O-R<sup>2</sup> where R<sup>2</sup> is hydrogen or an alkyl group;

n is 1, 2 or 3; and

m is an integer of 2 or more.

[0008] Preferably m is an integer from 2 to 6, for example 2, 3, 4, 5 or 6. When n is 2 or 3, the groups R<sub>1</sub> may be the same or different. When R-Y<sub>m</sub> contains more than one group -C(O)OR<sup>2</sup>, the groups R<sup>2</sup> may be the same or different.

[0009] In addition the present invention provides a water dispersible mixture of blocked polyisocyanates each of the formula



where the groups R are the same or different and each is an m valent group comprising an aliphatic, cycloaliphatic heterocyclic or aromatic group and wherein from 5 to 100 eq.wt% (preferably from 10 to 100 eq.wt%) of groups R comprise at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid, and each group Y, which may be the same or different, is a group of formula (II) as defined above.

[0010] According to a further embodiment, the invention provides a water dispersible product obtainable by

(a) contacting a polyisocyanate of formula (III)



wherein  $R^a$  is a q valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and q is an integer greater than 2,

with an active hydrogen-containing compound bearing a hydrophilic group which is  $-(CH_2CH_2O)_p-$  where p is 3 or more or with a polyhydroxy carboxylic acid group or derivative thereof to form a water dispersible polyisocyanate of formula  $R(NCO)_m$  where R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group comprising at least three consecutive ethylene oxide groups or a residue of a polyhydroxycarboxylic acid; and

(b) blocking the water dispersible polyisocyanate produced in step (a) with a pyrazole of formula (IV)



wherein  $R^1$  and n are as defined in relation to formula (I) above.

[0011] A substance is considered to be water dispersible for the purposes of the present invention if it forms a dispersion in water which is uniform on a macroscopic scale but consists of particles or droplets of the substance in water. Preferably the dispersion is a colloid, in which, for example, the particles or droplets of the dispersed substance have a diameter which is about the wavelength of light, for example about 500 nm. In general the particle or droplet is an aggregate of numerous molecules, but is too small to be seen with an optical microscope. The particles or droplets generally pass through most filter papers but can usually be detected by light-scattering, sedimentation and osmosis. Preferably the dispersion is an emulsion or sol of blocked polyisocyanate in water. An emulsion is generally a dispersion of liquid in liquid. A sol is generally a dispersion of a solid in a liquid.

[0012] An alkyl, alkenyl or aralkyl group may be a branched or straight chain group and may be substituted, for example with a halogen, such as fluorine, chlorine or bromine, or -OH. An alkyl group is preferably a  $C_1$  to  $C_6$  alkyl group, more preferably a  $C_1$  to  $C_4$  alkyl group, for example, methyl, ethyl, propyl, isopropyl, butyl, sec-butyl or tert-butyl. Most preferably it is methyl. An alkenyl group is preferably a  $C_2$  to  $C_6$  alkenyl group, for example  $C_2$ ,  $C_3$ ,  $C_4$ ,  $C_5$  or  $C_6$  alkenyl. An aralkyl group preferably has substituted or unsubstituted phenyl as the aryl portion. The alkyl portion is generally an alkyl group as defined above.

[0013] A polyhydroxy carboxylic acid is a compound having 2 or more hydroxyl groups and one or more carboxylic acid groups, such as dimethylolpropionic acid.

[0014] Preferably n is 2 or 3.

[0015] Preferably m is an integer from 2 to 6. More preferably m is 2 or 3.

[0016] A halogen is, for example chlorine, bromine or fluorine. Preferably it is chlorine or bromine.

[0017] An N-substituted carbamyl group is generally of formula  $-C(O)NR^3R^4$ , where  $R^3$  and  $R^4$  may be the same or different and each is hydrogen or an alkyl or alkenyl group, provided that  $R^3$  and  $R^4$  are not both hydrogen.

[0018] According to one embodiment the group R in the blocked isocyanate of formula (I) comprises at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid. According to a second embodiment, from 5 to 100% by equivalent weight of groups R comprise at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxycarboxylic acid.

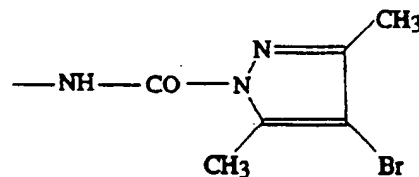
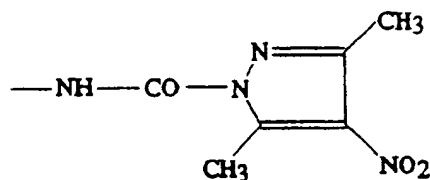
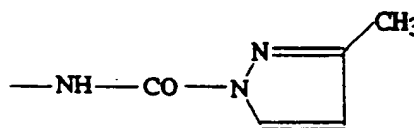
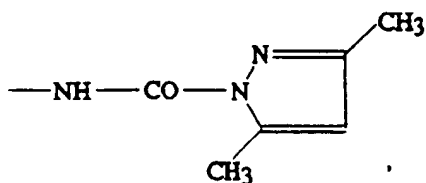
[0019] Consecutive ethylene oxide groups are groups bonded directly together. Three consecutive ethylene oxide groups can be represented as  $-(CH_2CH_2O)_3-$ . When R comprises consecutive ethylene oxide groups, it preferably comprises at least five, for example at least 7, 9 or 12 consecutive ethylene oxide groups. Preferably R comprises 0.01 to 25% by weight, based on the weight of the unblocked polyisocyanate, of ethylene oxide units, more preferably 0.5 to 25% by weight. R may comprise further ethylene oxide groups which are not consecutive with or bonded directly to

the three consecutive ethylene oxide groups.

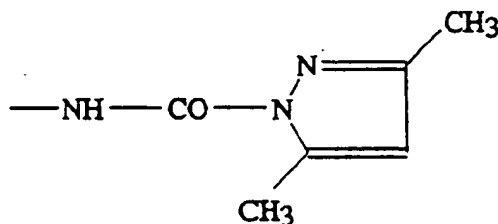
[0020] When R comprises residues of polyhydroxy carboxylic acid, it preferably comprises at least 2 residues, preferably at least 3, for example 5, 8, 12 or more residues of polyhydroxy carboxylic acid. Preferably R comprises 0.01 to 25% by weight, based on the weight of the unblocked polyisocyanate of polyhydroxy carboxylic acid residues, more preferably 0.5 to 25% by weight.

[0021] R may comprise residues of polyhydroxy carboxylic acid as well as at least three consecutive ethylene oxide groups. When less than 100 wt% of groups R comprise at least one residue of polyhydroxy carboxylic acid or at least three consecutive ethylene oxide groups, preferably at least 15 wt%, for example, at least 20, 30, 40, 50 or 60 wt% of groups R comprise at least one residue of polyhydroxy carboxylic acid or at least three consecutive ethylene oxide groups. When the polyhydroxy carboxylic acid is dimethylol propionic acid (DMPA) the ratio of isocyanate/hydroxyl groups is generally 0.05 to 0.7, preferably 0.2 to 0.3 on an equivalent weight basis, so isocyanate is in excess.

[0022] Preferably at least one group Y is



[0023] More preferably at least one group Y is



[0024] The present invention provides a process for producing a water dispersible blocked polyisocyanate which process comprises contacting a polyisocyanate of formula  $R(NCO)_m$  with a blocking agent, where R and m are defined as for the blocked isocyanate of formula (I). Preferably the resulting blocked polyisocyanate contains no free isocyanate groups.

[0025] The present invention further provides a process which comprises

- (a) contacting a conventional polyisocyanate of formula (III) as defined above with an active hydrogen-containing compound bearing a hydrophilic group which is  $-(CH_2CH_2O)_p-$  where p is 3 or more or a carboxylic acid group or derivative thereof to form a water dispersible polyisocyanate of formula  $R(NCO)_m$ ; and
- (b) blocking the water dispersible polyisocyanate produced in step (a) with a pyrazole of formula (IV) as defined above.

[0026] The blocking agents used in the present invention are pyrazoles of the formula (IV) as defined above. Examples of suitable pyrazoles include

3,5-dimethylpyrazole, 3-methylpyrazole,

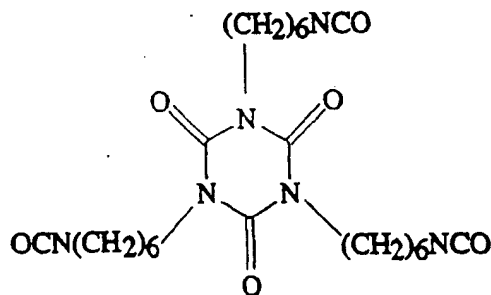
4-nitro-3,5-dimethylpyrazole and 4-bromo-3,5-dimethylpyrazole. The preferred blocking agent is 3,5-dimethylpyrazole.

[0027] The polyisocyanate of formula  $R(NCO)_m$  which is to be blocked is a water dispersible organic polyisocyanate suitable for crosslinking compounds containing active hydrogen. Suitable polyisocyanates comprise, for example, aliphatic groups including cycloaliphatic, aromatic, heterocyclic, and mixed aliphatic aromatic groups. The polyisocyanates contain 2, 3 or more isocyanate groups.

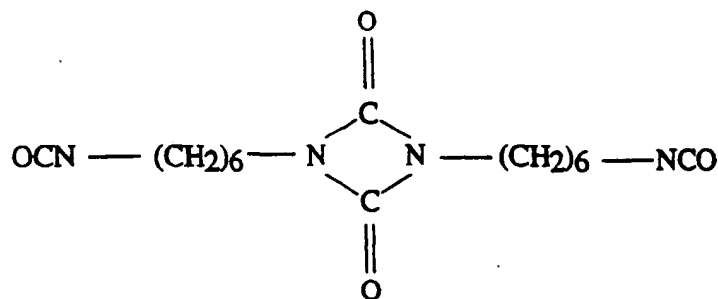
[0028] The polyisocyanate of formula  $R(NCO)_m$  may be, for example, selected from those described in US 4,522,851 or may be a polyisocyanate prepolymer obtained by reacting a conventional polyisocyanate, such as a diisocyanate, with a compound comprising at least three consecutive ethylene oxide units or at least one polyhydroxy carboxylic acid residue.

[0029] The conventional polyisocyanates are generally  $C_1$  to  $C_{12}$  alkylene diisocyanates, or dimers or trimers thereof, aryl diisocyanates or cycloalkyl diisocyanates. The conventional polyisocyanates include, for example toluene diisocyanate, such as 2,4- and 2,6-toluene diisocyanate ethylene diisocyanate and mixtures thereof, propylene diisocyanate, 4,4-diphenylmethane diisocyanate, p-phenylene diisocyanate, tetramethylene diisocyanate, hexamethylene diisocyanate, decamethylene diisocyanate, dodecamethylene diisocyanate, 2,4,4-trimethylhexamethylene-1,6 diisocyanate, phenylene diisocyanate, tolylene or naphthylene diisocyanate, 4,4'-methylene-bis(phenyl isocyanate), 4,4'-ethylene-bis(phenyl isocyanate),  $\omega,\omega'$ -diisocyanato-1,3-dimethyl benzene,  $\omega,\omega'$ -diisocyanato-1,4-dimethylcyclohexane,  $\omega,\omega'$ -diisocyanato-1,4-dimethyl benzene,  $\omega,\omega'$ -diisocyanato-1,3-dimethylcyclohexane, 1-methyl-2,4-diisocyanatocyclohexane, 4,4'-methylene-bis(cyclohexyl isocyanate), 3-isocyanato-methyl-3,5,5-trimethylcyclohexyl isocyanate, dim- or acid-diisocyanato,  $\omega,\omega'$ -diisocyanatodiethyl benzene,  $\omega,\omega'$ -diisocyanatodimethyl toluene,  $\omega,\omega'$ -diisocyanatodiethyl toluene, fumaric acid bis(2-isocyanato ethyl) ester, triphenylmethane triisocyanate, 1,4-bis(2-isocyanato-prop-2-yl) benzene and 1,3-bis(2-isocyanato prop-2-yl) benzene.

[0030] Particularly preferred conventional polyisocyanates are the biuret, uretdione or isocyanurate of a  $C_1$  to  $C_{12}$  alkylene diisocyanate, such as 1,6-hexamethylene diisocyanate (HMDI). The isocyanurate of HMDI is the isocyanate "trimer" and has the structure



[0031] The uretdione of HMDI is the "dimer" and has the structure

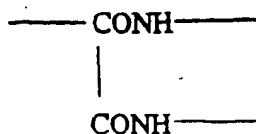


[0032] The polyisocyanate prepolymers may be obtained by reaction of an excess amount of the conventional polyisocyanate with an active hydrogen containing compound, for example, a polyol or a polyamine, such as a lower molecular weight polyol or polyamine, for example having a molecular weight of 300 or less, or a medium molecular weight polyol or polyamine, for example a polyol or polyamine having a molecular weight of 300 to 8000.

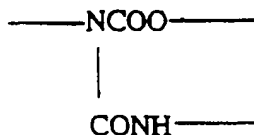
[0033] In addition to the at least one residue of polyhydroxy carboxylic acid or at least three consecutive ethylene oxide groups, the polyol or polyamine preferably comprises, for example, dimers, trimers or polymers of one or more of ethylene glycol, propylene glycol, 1,3-butylene glycol neopentyl glycol, 2,2,4-trimethyl-1,3-pentane diol, hexamethylene glycol, cyclohexane diethanol, hydrogenated bisphenol-A, trimethylol propane, trimethylol ethane, 1,2,6-hexane triol, glycerine, sorbitol or pentaerythritol.

[0034] Preferably the polyol or polyamine comprises residues of at least one of diethylene glycol, triethylene glycol or polyethylene glycol, preferably in an amount that the resulting unblocked polyisocyanate comprises 0.01 to 25% by weight of ethylene oxide units. Preferably the active hydrogen containing compound is a polyoxyalkylene amine such as Jeffamine M-1000.

[0035] The di- or polyisocyanate obtained by the above reaction may comprise a biuret group having the structure



or an allophanate group having the structure



The polyisocyanate may be cyclic, for example a derivative, such as an ester, of isocyanuric acid.

[0036] Preferably the isocyanate group of the polyisocyanate is not bonded directly to an aromatic nucleus in the group R.

[0037] The reaction between the polyisocyanate  $\text{R}(\text{NCO})_m$  and the blocking group is exothermic. Since the reaction product will dissociate if the temperature is raised sufficiently, cooling may be required to keep the temperature of the reaction mixture down, preferably to 80°C or less. The resulting blocked polyisocyanate is then recovered and may be isolated or purified.

[0038] The present invention further provides an aqueous dispersion of at least one blocked isocyanate as defined herein. Surprisingly the aqueous dispersions are storage stable for at least four months at room temperature whilst providing blocked polyisocyanates which dissociate at relatively low temperatures.

[0039] At 40°C these dispersions have been found to be storage stable for several weeks, and up to several months.

This has significant commercial benefit, allowing users in warm climates to take advantage of the low unblocking temperatures whilst retaining adequate storage stability.

[0040] The dispersions are formed by, for example, stirring or agitating a mixture of water and the blocked isocyanate. Typically the dispersion is formed using an anchor stirrer at 250 to 300 rpm. It is also possible to use a high speed "Greaves" mixer to disperse the product.

[0041] The dispersions may additionally comprise at least one of an emulsifier, a detergent, a colourant, a pigment, a resin, a surfactant, a catalyst or an antioxidant.

Preferably the dispersions contain only water and blocked isocyanate. Generally the dispersion comprises from 5 to 95% by weight, based on the weight of the dispersion, of blocked polyisocyanate, preferably 30 to 70%, more preferably 35 to 60% by weight of blocked polyisocyanates.

[0042] The present invention further provides a water-based coating composition which comprises an aqueous dispersion as defined above and at least one compound containing an active hydrogen, selected from, for example, alcohols, amines, polyhydroxy-polyesters, polyhydroxy polyethers, polylactones, hydroxypolycarbonates, polythioethers, polyacetals, polyether esters, polyester amides and polyamide-polyamine resins, e.g. the product from a dimer fatty acid and an aliphatic polyamide.

[0043] Preferably the compound containing an active hydrogen atom is an acrylic resin containing a carboxylic acid group and hydroxy groups, a water dispersible polyester or polyether resin or a hydroxyacrylic resin containing a tertiary amine group, or polymers thereof.

[0044] Generally the coating composition comprises from 10 to 90% by weight based on the weight of the composition of the compound containing an active hydrogen atom.

[0045] Typically the coating composition may comprise at least one of an emulsifier, a detergent, a colourant, a pigment, a resin, a surfactant, a catalyst, an antioxidant, a dispersing aid, a fungicide, a viscosity modifier, a defoamer, a flow additive or a coalescing solvent.

[0046] The coating compositions of the present invention conveniently provide one component storage stable coating formulations, which are generally stable for at least four months at room temperature, that is at a temperature between 15 and 22°C, generally, 16, 17 or 18°C.

[0047] Typically a coating composition according to the invention will comprise components in the following proportions:

Component	Parts by weight
1) Water	8.0
2) Dispersing Aid	0.3
3) Dimethylaminoethanol	0.6
4) Fungicide	0.1
5) Titanium Dioxide	18.0
6) Viscosity Modifier	3.0
7) Defoamer	0.3
8) Flow Additive	0.3
9) Acrylic Emulsion (45% solids)	47.0
10) Blocked Isocyanate	22.0
11) Coalescing Solvent	0.4

[0048] According to a further embodiment of this invention, the coating is a paint composition comprising a pigment carrier containing active hydrogen groups, a pigment and an aqueous dispersion of a compound of formula I.

[0049] These paints usually comprise a pigment dispersed in an aqueous dispersion of a pigment carrier. Preferably the pigment carrier is a resin containing an active hydrogen, which resin is to be crosslinked by the polyisocyanate. Preferably the paint contains 0.5 to 2 blocked isocyanate groups per active hydrogen containing group. Suitable active hydrogen containing resins include polyamide-polyamine resins, e.g. the product from a dimer fatty acid and an aliphatic polyamide, carboxylic acid group containing acrylic resins, or tertiary amine group containing hydroxyacrylic resins and polymers thereof.

[0050] The total concentration of the dispersed solid will, of course, depend upon the process for which the paint is to be used. Various standard additives such as surface active agents, catalysts and anti-oxidants may also be incorporated.

[0051] The coatings according to the invention may be deposited electrophoretically or conventionally e.g. by spray depositing, dipping, applying with a roller or brush, transfer coating, screen painting, electrostatic spraying, using a

doctor blade or electrocoating or by other means onto the articles to be coated and then subsequently hardened by heating the deposited coating to crosslink the compound containing an active hydrogen.

[0052] The electrophoretic deposition process is well known and involves the use of a cathode and an anode in contact with a bath containing the paint. The surface to be coated is the surface of one of the electrodes. On applying a voltage of generally 1 to 3,000 volts across the electrodes the paint is deposited onto the surface of one of the electrodes.

[0053] The coated article is removed from the bath and stoved e.g. baked in an oven. The blocking groups dissociate from the isocyanate groups, which then react with the compound containing the active hydrogen. This results in crosslinking and hardening of the coating. Coating compositions according to this invention are generally hardened at temperatures from 100 to 180°C, for instance at up to 140°C or, preferably, up to 120°C.

[0054] The present invention further provides the use of an aqueous dispersion of a blocked isocyanate as defined herein as a coating composition, such as a paint.

[0055] Other uses of the aqueous dispersions and coating compositions of the invention include clear coatings (similar to paints but lacking opaque pigments) and water based textile coatings and crosslinkers for fabrics. The low unblocking temperature permits the aqueous dispersions and coating compositions to be used to coat relative heat sensitive substrates such as plastics which would melt or degrade at higher storing temperature. A preferred use of the aqueous dispersions and coating compositions is in the automotive industry, for instance in or as primers, basecoats, topcoats and lacquers for automobiles.

[0056] The present invention further provides a coating process which comprises applying the coating to an item and heating it to achieve hardening of the coating.

[0057] The invention is illustrated by the following Examples.

#### EXAMPLES

Example 1 - Production of aqueous dispersion of blocked isocyanate.

[0058] The following reactants were used:

		Weight %
1)	1,6-Hexamethylene diisocyanate trimer	30
2)	Polyoxyalkylene amine (Jeffamine M-1000)	3
3)	3,5-Dimethyl pyrazole (Blocking agent)	16
4)	Butyl glycol ether (solvent)	7
5)	Sodium sulphosuccinate (Disponil SUS 87)	4
6)	Water	40

(1) was added to a reaction vessel. (2) was slowly added to the reaction vessel. The vessel was heated to 60 to 70°C until an isocyanate content of 20 to 21 mol % was reached. The temperature was maintained at 60 to 70°C while (3) was added slowly until an isocyanate content of zero was reached. (4) and (5) were added and mixed for 5 minutes. Water was added and a dispersion was formed using a high speed mixer. Jeffamine M-1000 is the active hydrogen-containing compound which reacts with the HMDI trimer to form a polyisocyanate prepolymer. Sodium sulphosuccinate is an ionic surfactant which helps to control the particle size of the dispersion.

Example 2 Production of aqueous dispersion of blocked isocyanate

[0059] The following reactants were used:

		Weight %
1)	1,6 Hexamethylene diisocyanate trimer	26.7
2)	n-Methyl pyrrolidone	6.0
3)	Dimethyl pyrazole	11.3
4)	Dimethylol propionic acid	1.9
5)	DMAMP 80 (Angus Chemie)	2.0
6)	Water	52.1



1) was added to a reaction vessel. (2) was added and the vessel heated to 60-70°C. The temperature was maintained at 60-70°C while (3) was added slowly until an isocyanate content of 2.8% was reached. (4) was added and the reaction continued until an isocyanate content of zero was reached. The batch was cooled to 60°C before adding (5) and (6).

5 **Example 3 - Production of white paint composition.**

[0060]

10	Component	Parts by weight
	1) Water	8.0
	2) Dispersing aid (Dispex 40)	0.3
	3) Dimethylaminoethanol	0.6
	4) Fungicide (Acticide SPX)	0.1
15	5) Titanium dioxide	18.0
	6) Viscosity modifier (Rheovis CR2)	3.0
	7) Defoamer (Foamex 1488)	0.3
	8) Flow additive (Aerosol 0775)	0.3
20	9) Acrylic emulsion (Xenacryl (45% solids) DP 9B/1283)	47.0
	10) Blocked isocyanate	22.0
	11) Coalescing solvent (Ectrapro EEP)	0.4

Components (1), (2), (4), (5), (7), 0.06 parts by weight of component (3) and 1.5 parts by weight of component (6) were formed into a premixture under high shear in order to achieve good pigment dispersion (maximum particle size: Hegmann 5). The titanium dioxide was added slowly to assist wetting. Components (8) to (11) and the remainder of components (3) and (6) were added and mixed under high shear for 10 minutes.

[0061] The components (2), (4), (6), (7), (8), (9), (10) and (11) were obtained from the following manufacturers:

30	2	Dispersing aid	Dispex 40	Allied Colloids
	4	Fungicide	Acticide SPX	Thor Industrial Biocides
	6	Viscosity modifier	Rheovis CR2	Allied Colloids
	7	Defoamer	Foamex 1488	Tego Chemie Service
	8	Flow additives	Aerosol 0775	Cytec Industries
35	9	Acrylic Emulsion	Xenacryl DP9B/1283	Baxenden Chemicals Ltd.
	10	Blocked isocyanate	Obtained by reaction of HMDI trimer with DMPA and blocked with 3,5-dimethylpyrazole (see example 2)	
40	11	Coalescing solvent	Extrapro EEP	Eastman Chemical Ltd.

**Example 4**

Coatings

45 [0062] The white paint composition of Example 3 was coated onto various substrates and stored at 120°C for 45 minutes. The resultant coatings were tested with the following results

Table 1

50	TEST	RESULT	TEST METHOD
	Opacity	96%	R+D Method 22
	Gloss 20°	51%	R+D Method 22
	60°	82%	
55	Reverse Impact: 1.8kg weight (1.0m)	PASSED	ASTM D2794-92 Steel Panels
	Bend Test: Shim steel panels (3mm cylindrical mandrel)	PASSED	BS3900 Part E1
	Cross cut adhesion:	Rating	BS3900 Part E6

Table 1 (continued)

TEST	RESULT	TEST METHOD
Substrate		
Smooth steel	0	ISO 2409
Matt steel	0	
Tin plate steel	0	
Aluminium	0	
Chrome treated aluminium	0	
Pencil Hardness		ASTM D3363-92a
Gouge Hardness	3H	
Scratch Hardness	2H	
Weathering after 280 hours		ASTM G5388 4hrs UVB @ 60°C 4hrs condensation @ 50°C
Gloss retention	95%	
Observations on steel substrate	No rusting	
Acetone resistance (double rubs)	>100 units	Standard

Unless otherwise stated, substrates were standard steel test panels.

Example 5 - Production of clear coat formulation

[0063]

Component		Parts by weight
1)	Xenacryl DP 9B/1345	54.1
2)	Blocked polyisocyanate of Example 2	25.4
3)	Tegowet KL 245	0.5
4)	Estasol	5.0
5)	Ectapro EEP	2.0
6)	Water	13.0

Method

[0064] (1) and (2) were added to a vessel and mixed well. (3), (4) and (5) were added and mixed thoroughly before adding (6).

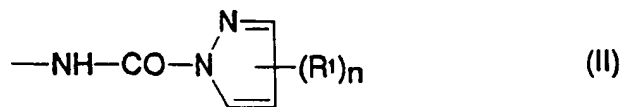
Suppliers	
1)	Xenacryl DP9B/1345 Acrylic emulsion Baxenden Chemicals
3)	Tegowet KL245 Flow additive Tego Chemie
4)	Estasol Coalescing solvent Chemoxy International

**Claims**

1. A water dispersible blocked polyisocyanate of formula (I)



where R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and comprising at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid, and each group Y, which may be the same or different, is a group of formula (II)



where each  $\text{R}^1$  is the same or different when  $n$  is more than 1 and each  $\text{R}^1$  is an alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl,  $\text{NO}_2$ , halogen or a group  $\text{—C(O)—O—R}^2$

where  $\text{R}^2$  is hydrogen or an alkyl group;

$n$  is 0, 1, 2 or 3; and

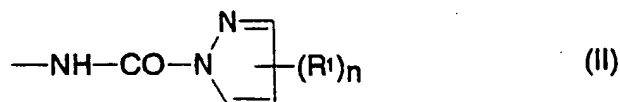
$m$  is an integer of 2 or more.

2. A water dispersible mixture of blocked polyisocyanates each of the formula



where the groups  $\text{R}$  are the same or different and each is an  $m$  valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and wherein from 5 to 100 eq. wt% of  $\text{R}$  groups comprise at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid,

and each group  $\text{Y}$ , which may be the same or different, is a group of formula (II)



where the groups  $\text{R}^1$  are the same or different when  $n$  is more than 1 and

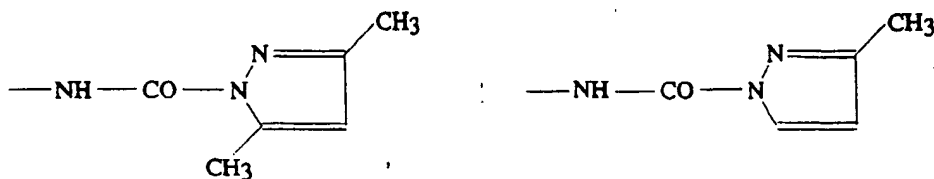
each  $\text{R}^1$  is an alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl,  $\text{NO}_2$ , halogen or a group  $\text{—C(O)—O—R}^2$

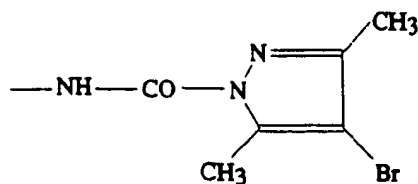
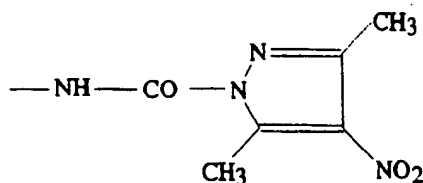
where  $\text{R}^2$  is hydrogen or an alkyl group;

$n$  is 0, 1, 2 or 3; and

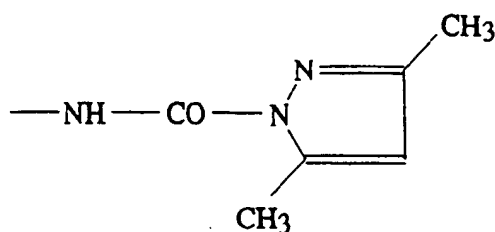
$m$  is an integer of 2 or more.

3. A blocked polyisocyanate according to claim 1 or 2 wherein at least one group  $\text{Y}$  is





- 15
4. A blocked polyisocyanate according to claim 3 wherein at least one group Y is



5. A blocked polyisocyanate according to any one of the preceding claims wherein m is from 2 to 6.

6. A water dispersible product obtainable by a process comprising at least

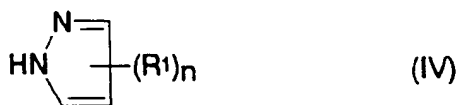
- 30 (a) contacting a polyisocyanate of formula (III)



35 wherein  $\text{R}^a$  is an q valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and q is an integer greater than 2 with an active hydrogen-containing compound bearing a hydrophilic group which is  $\text{—(CH}_2\text{CH}_2\text{O)}_p\text{—}$  where p is 3 or more or with a polyhydroxy carboxylic acid group or derivative thereof to form a water dispersible polyisocyanate of formula  $\text{R}(\text{NCO})_m$  wherein R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group, comprising at least three consecutive ethylene oxide groups or

40 a residue of a polyhydroxy carboxylic acid; and

(b) blocking the water dispersible polyisocyanate produced in step (a) with a pyrazole of formula (IV)



50 wherein each  $\text{R}^1$  is the same or different when n is more than 1 and each  $\text{R}^1$  is an alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl,  $\text{NO}_2$ , halogen or a group  $\text{—C(O)—O—R}^2$  where  $\text{R}^2$  is hydrogen or an alkyl group, n is 0, 1, 2 or 3; and m is an integer of 2 or more.

7. A process for producing a water dispersible blocked polyisocyanate as claimed in any one of the preceding claims which process comprises contacting a polyisocyanate of formula



wherein R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and comprising at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid and m is an integer of 2 or more with a pyrazole of formula (IV)

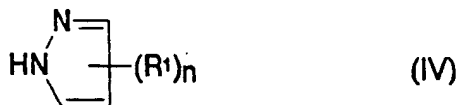


where each R<sup>1</sup> is the same or different when n is more than 1 and each R<sup>1</sup> is an alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl, NO<sub>2</sub>, halogen or a group -C(O)-O-R<sup>2</sup> where R<sup>2</sup> is hydrogen or an alkyl group and n is 0, 1, 2 or 3.

8. A process for producing a water dispersible blocked polyisocyanate as claimed in any one of claims 1 to 6 which process comprises contacting a polyisocyanate of formula



wherein R is an m valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and comprising at least three consecutive ethylene oxide groups or at least one residue of a polyhydroxy carboxylic acid and m is an integer of 2 or more with a pyrazole of formula (IV)



where each R<sup>1</sup> is the same or different when n is more than 1 and each R<sup>1</sup> is an alkyl, alkenyl, aralkyl, N-substituted carbamyl, phenyl, NO<sub>2</sub>, halogen or a group -C(O)-O-R<sup>2</sup> where R<sup>2</sup> is hydrogen or an alkyl group and n is 0, 1, 2 or 3 such that the reaction product contains no free isocyanate groups.

9. A process according to claim 7 or 8 which comprises the initial step of contacting a polyisocyanate of formula (III)



wherein R<sup>a</sup> is a q valent group comprising an aliphatic, cycloaliphatic, heterocyclic or aromatic group and q is an integer greater than 2 with an active hydrogen-containing compound bearing a hydrophilic group which is -(CH<sub>2</sub>CH<sub>2</sub>O)<sub>p</sub>-where p is 3 or more or a carboxylic acid group or derivative thereof to form a water dispersible polyisocyanate of formula R(NCO)<sub>m</sub>.

10. An aqueous dispersion of at least one blocked polyisocyanate as claimed in any one of claims 1 to 6.
11. A coating composition which comprises a dispersion as claimed in claim 10 and a compound containing an active hydrogen.
12. A coating composition according to claim 11 which is a paint.
13. A coating composition according to claim 11 or claim 12 which comprises a pigment and a pigment carrier, wherein the pigment carrier is the compound containing an active hydrogen.
14. A composition according to any one of claims 11, 12 and 13 which contains 0.5 to 2 blocked isocyanate groups per active hydrogen containing group.

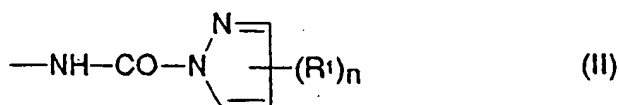
15. A method of coating a substrate which comprises applying a composition as claimed in any one of claims 11 to 14 to a substrate and then heating the deposited composition to crosslink the coating.
16. A method according to claim 15 which additionally comprises the step of heating the coated substrate.
17. A method according to claim 15 or claim 16 wherein the composition is applied by electrodeposition.

# Patentansprüche

1. Wasserdispergierbares blockiertes Polyisocyanat der Formel (I)



worin R eine m-wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe und umfassend mindestens drei aufeinanderfolgende Ethylenoxidgruppen oder mindestens einen Rest einer Polyhydroxycarbonsäure, und jede Gruppe Y, die gleich oder verschieden sein kann, eine Gruppe ist der Formel (II)

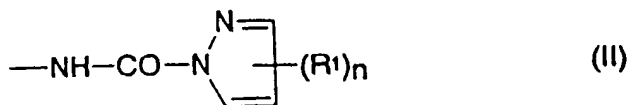


worin jedes  $R^1$  gleich oder verschieden ist, wenn n mehr als 1 ist, und jedes  $R^1$  ein Alkyl, Alkenyl, Aralkyl, N-substituiertes Carbamyl, Phenyl,  $NO_2$ , Halogen oder eine Gruppe  $-C(O)-O-R^2$  ist, worin  $R^2$  Wasserstoff oder eine Alkylgruppe ist; n 0, 1, 2 oder 3 ist; und m eine ganze Zahl von 2 oder mehr ist.

2. Wasserdispergierbares Gemisch von blockierten Polyisocyanaten, die jeweils von folgender Formel sind

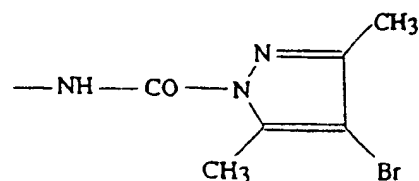
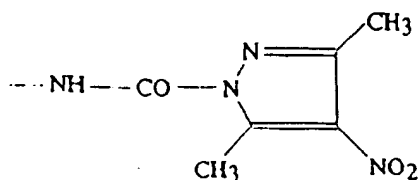
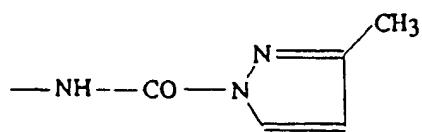
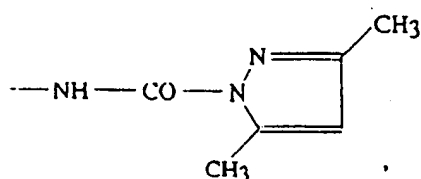


worin die Gruppen R gleich oder verschieden sind und jedes eine m-wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe, und wobei 5 bis 100 Äq.gew.-% der R-Gruppen mindestens drei aufeinanderfolgende Ethylenoxidgruppen oder mindestens einen Rest einer Polyhydroxycarbonsäure umfassen, und jede Gruppe Y, die gleich oder verschieden sein kann, eine Gruppe ist der Formel (II)

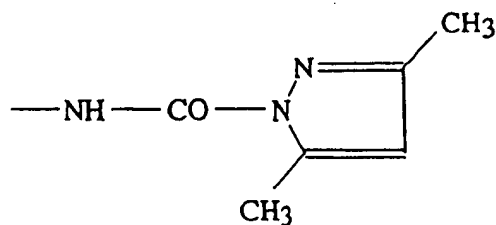


worin die Gruppen  $R^1$  gleich oder verschieden ist, wenn n mehr als 1 ist und jedes  $R^1$  ein Alkyl, Alkenyl, Aralkyl, N-substituiertes Carbamyl, Phenyl,  $NO_2$ , Halogen oder eine Gruppe  $-C(O)-O-R^2$  ist, worin  $R^2$  Wasserstoff oder eine Alkylgruppe ist; n 0, 1, 2 oder 3 ist; und m eine ganze Zahl von 2 oder mehr ist.

3. Blockiertes Polyisocyanat nach Anspruch 1 oder 2, wobei mindestens eine Gruppe Y folgendes ist:



4. Blockiertes Polyisocyanat nach Anspruch 3, wobei mindestens eine Gruppe Y folgendes ist:



5. Blockiertes Polyisocyanat nach einem der vorangehenden Ansprüche, wobei m 2 bis 6 ist.

6. Wasserdispergierbares Produkt, herstellbar durch ein Verfahren, umfassend zumindest

(a) das Zusammenbringen eines Polyisocyanats der Formel (III)

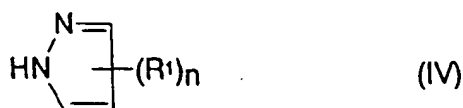


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worin  $R^a$  eine q-wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe, und q eine ganze Zahl von größer 2 ist, mit einer aktiven Wasserstoff-haltigen Verbindung ist, die eine hydrophile Gruppe trägt, die  $-(CH_2CH_2O)_p-$  ist, worin p 3 oder mehr ist, oder mit einer Polyhydroxycarbonsäure-Gruppe oder einem Derivat davon, zum Erhalt eines wasserdispergierbaren Polyisocyanats der Formel  $R(NCO)_m$ , wobei R eine m-wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe und umfassend mindestens drei aufeinanderfolgende Ethylenoxidgruppen oder mindestens einen Rest einer Polyhydroxycarbonsäure; und

(b) Blockieren des in Schritt (a) hergestellten wasserdispergierbaren Polyisocyanats mit einem Pyrazol der Formel (IV)

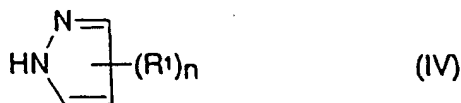


wobei jedes  $\text{R}^1$  gleich oder verschieden ist, wenn  $n$  mehr als 1 ist, und jedes  $\text{R}^1$  ein Alkyl, Alkenyl, Aralkyl, N-substituiertes Carbamyl, Phenyl,  $\text{NO}_2$ , Halogen oder eine Gruppe  $-\text{C}(\text{O})-\text{O}-\text{R}^2$  ist, worin  $\text{R}^2$  Wasserstoff oder eine Alkylgruppe ist;  $n$  0, 1, 2 oder 3 ist; und  $m$  eine ganze Zahl von 2 oder mehr ist.

7. Verfahren zur Herstellung eines wasserdispergierbaren blockierten Polyisocyanats nach einem der vorangehenden Ansprüche, welches Verfahren das Zusammenbringen eines Polyisocyanats umfaßt der folgenden Formel



worin  $\text{R}$  eine  $m$ -wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe und umfassend mindestens drei aufeinanderfolgende Ethylenoxidgruppen oder mindestens einen Rest einer Polyhydroxycarbonsäure und  $m$  eine ganze Zahl von 2 oder mehr ist, mit einem Pyrazol der Formel (IV)

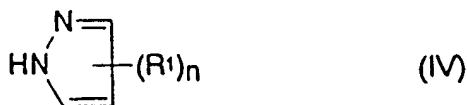


worin jedes  $\text{R}^1$  gleich oder verschieden ist, wenn  $n$  mehr als 1 ist, und jedes  $\text{R}^1$  ein Alkyl, Alkenyl, Aralkyl, N-substituiertes Carbamyl, Phenyl,  $\text{NO}_2$ , Halogen oder eine Gruppe  $-\text{C}(\text{O})-\text{O}-\text{R}^2$  ist, worin  $\text{R}^2$  Wasserstoff oder eine Alkylgruppe ist und  $n$  0, 1, 2 oder 3 ist.

8. Verfahren zur Herstellung eines wasserdispergierbaren blockierten Polyisocyanats nach einem der Ansprüche 1 bis 6, welches Verfahren das Zusammenbringen eines Polyisocyanats umfaßt der folgenden Formel



worin  $\text{R}$  eine  $m$ -wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe und umfassend mindestens drei aufeinanderfolgende Ethylenoxidgruppen oder mindestens einen Rest einer Polyhydroxycarbonsäure und  $m$  eine ganze Zahl von 2 oder mehr ist, mit einem Pyrazol der Formel (IV)



worin jedes  $\text{R}^1$  gleich oder verschieden ist, wenn  $n$  mehr als 1 ist, und jedes  $\text{R}^1$  ein Alkyl, Alkenyl, Aralkyl, N-substituiertes Carbamyl, Phenyl,  $\text{NO}_2$ , Halogen oder eine Gruppe  $-\text{C}(\text{O})-\text{O}-\text{R}^2$  ist, worin  $\text{R}^2$  Wasserstoff oder eine Alkylgruppe ist und  $n$  0, 1, 2 oder 3 ist, sodaß das Reaktionsprodukt keine freien Isocyanatgruppen enthält.



9. Verfahren nach Anspruch 7 oder 8, welches den Ausgangsschritt des Zusammenbringens eines Polyisocyanats der Formel (III) umfaßt



worin  $R^a$  eine q-wertige Gruppe ist, umfassend eine aliphatische, cycloaliphatische, heterozyklische oder aromatische Gruppe, und q eine ganze Zahl von größer 2 ist, mit einer aktiven Wasserstoff-haltigen Verbindung, die eine hydrophile Gruppe trägt, die  $-(CH_2CH_2O)_p-$  ist, worin p 3 oder mehr ist, oder mit einer Carbonsäure-Gruppe oder einem Derivat davon, zum Erhalt eines wasserdispergierbaren Polyisocyanats der Formel  $R(NCO)_m$ .

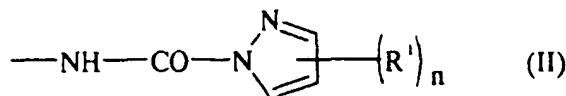
10. Wässrige Dispersion mindestens eines blockierten Polyisocyanats nach einem der Ansprüche 1 bis 6.
11. Beschichtungszusammensetzung, die eine Dispersion nach Anspruch 10 und eine Verbindung, enthaltend einen aktiven Wasserstoff, umfaßt.
12. Beschichtungszusammensetzungen nach Anspruch 11, welche eine Farbe ist.
13. Beschichtungszusammensetzungen nach Anspruch 11 oder Anspruch 12, welche ein Pigment und ein Pigmentträger ist, wobei der Pigmentträger die Verbindung ist, enthaltend einen aktiven Wasserstoff.
14. Zusammensetzung nach einem der Ansprüche 11, 12 und 13, welche 0,5 bis 2 blockierte Isocyanatgruppen pro aktiver Wasserstoff-haltiger Gruppe enthält.
15. Verfahren zur Beschichtung eines Substrats, welches das Auftragen einer Zusammensetzung nach einem der Ansprüche 11 bis 14 auf ein Substrat und dann das Erhitzen der abgelagerten Zusammensetzung zur Vernetzung der Beschichtung umfaßt.
16. Verfahren nach Anspruch 15, welches außerdem den Schritt des Erhitzens des beschichteten Substrats umfaßt.
17. Verfahren nach Anspruch 15 oder Anspruch 16, wobei die Zusammensetzung durch elektrophoretische Beschichtung aufgebracht wird.

#### Revendications

1. Un polyisocyanate bloqué dispersible dans l'eau de formule (I)



dans laquelle R est un groupe m-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique et comprenant au moins trois groupes consécutifs d'oxyde d'éthylène ou au moins un résidu d'un acide carboxylique polyhydroxylé, et chaque groupe Y, qui peut être le même ou différent, est un groupe de la formule (II),

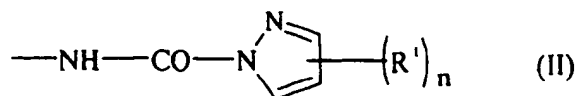


dans laquelle chaque  $R^1$  est le même ou est différent lorsque n est supérieur à 1 et chaque  $R^1$  est un alkyle, un alkényle, un aralkyle, un carbamyle N-substitué, un phényle,  $NO_2$ , un halogène ou un groupe  $-C(O)-O-R^2$  dans lequel  $R^2$  est un hydrogène ou un groupe alkyle ;  
n est égal à 0, 1, 2 ou 3 ; et  
n est un entier égal à 2 ou plus.

2. Un mélange dispersible dans l'eau de polyisocyanates bloqués chacun de formule



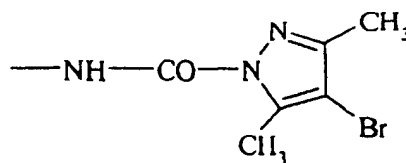
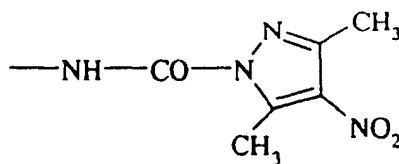
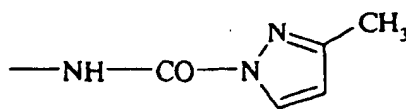
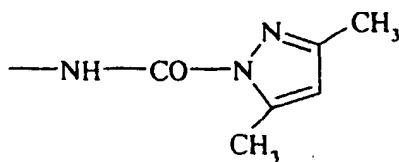
dans laquelle les groupes R sont les mêmes ou sont différents et chacun est un groupe m-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique et dans lequel 5 à 100 éq. en poids des groupes R comprennent au moins trois groupes d'oxyde éthylène consécutifs ou au moins un résidu d'un acide carboxylique polyhydroxylé,  
et chaque groupe Y, qui peut être le même ou différent, est un groupe de formule (II)



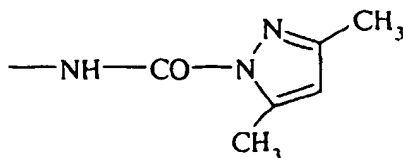
dans lequel les groupes  $R^1$  sont les mêmes ou sont différents lorsque n est supérieur à 1 et chaque  $R^1$  est un alkyle, un alkenyle, un aralkyle, un carbamyle N-substitué, un phényle,  $NO_2$ , un halogène ou un groupe  $-C(O)-O-R^2$  dans lequel  $R^2$  est un hydrogène ou un groupe alkyle ;

n est égal à 0, 1, 2 ou 3 ; et  
m est un entier égal à 2 ou plus.

3. Un polyisocyanate bloqué selon la revendication 1 ou 2 dans lequel au moins un groupe Y est



4. Un polyisocyanate bloqué selon la revendication 3 dans lequel au moins un groupe Y est



5. Un polyisocyanate bloqué selon l'une quelconque des revendications précédentes, dans lequel m est compris entre 2 et 6.

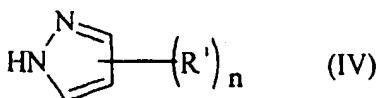
6. Un produit dispersible dans l'eau, susceptible d'être obtenu par un procédé comprenant au moins les étapes consistant à

(a) mettre en contact un polyisocyanate de formule (III)



dans lequel  $R^a$  est un groupe q-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique et q est un entier supérieur à 2 avec un composé contenant de l'hydrogène actif portant un groupe hydrophile qui est  $-(CH_2CH_2O)_p-$  dans lequel p est 3 ou plus ou avec un groupe acide carboxylique polyhydroxylé ou un dérivé de celui-ci en vue de former un polyisocyanate dispersible dans l'eau de formule  $R(NCO)_m$  dans lequel R est un groupe m-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique, comprenant au moins trois groupes d'oxyde éthylène consécutifs ou un résidu d'un acide carboxylique polyhydroxylé; et

(b) bloquer le polyisocyanate dispersible dans l'eau tel que produit à l'étape (a) avec un pyrazole de formule (IV)

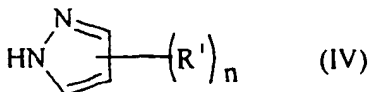


dans lequel chaque  $R^1$  est le même ou est différent lorsque n est supérieur à 1 et chaque  $R^1$  est un alkyle, un alkényle, un aralkyle, un carbamyle N-substitué, un phényle,  $NO_2$ , un halogène ou un groupe  $-C(O)-O-R^2$  dans lequel  $R^2$  est un hydrogène ou un groupe alkyle, n est 0, 1, 2 ou 3; et m est un entier égal à 2 ou plus.

7. Un procédé destiné à la production d'un polyisocyanate bloqué dispersible dans l'eau tel que revendiqué dans l'une quelconque des revendications précédentes, lequel procédé comprend la mise en contact d'un polyisocyanate de formule



dans lequel R est un groupe m-valent comprenant un groupe aliphatique, un groupe cycloaliphatique, un groupe hétérocyclique ou aromatique et comprenant au moins trois groupes d'oxyde éthylène consécutifs ou au moins un résidu d'un acide carboxylique polyhydroxylé et m est un entier égal à 2 ou plus avec un pyrazole de formule (IV)

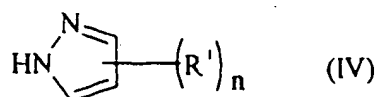


dans lequel chaque  $R^1$  est le même ou est différent lorsque n est supérieur à 1 et chaque  $R^1$  est un alkyle, un alkényle, un aralkyle, un carbamyle N-substitué, un phényle,  $NO_2$ , un halogène ou un groupe  $-C(O)-O-R^2$  dans lequel  $R^2$  est un hydrogène ou un groupe alkyle et n est 0, 1, 2 ou 3.

8. Procédé destiné à la production d'un polyisocyanate bloqué dispersible dans l'eau tel que revendiqué dans l'une quelconque des revendications 1 à 6, lequel procédé comprend la mise en contact d'un polyisocyanate de formule



dans lequel R est un groupe m-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique et comprenant au moins trois groupes d'oxyde d'éthylène consécutifs ou au moins un résidu d'un acide carboxylique polyhydroxylé et m est un entier égal à 2 ou plus avec un pyrazole de formule (IV)



dans lequel chaque  $R^1$  est le même ou est différent lorsque  $n$  est supérieur à 1 et chaque  $R^1$  est un alkyle, un alkényle, un aralkyle, un carbamyle N-substitué, un phényle,  $NO_2$ , un halogène ou un groupe  $-C(O)-O-R^2$  dans lequel  $R^2$  est un hydrogène ou un groupe alkyle et  $n$  est 0, 1, 2 ou 3 de telle sorte que le produit de réaction ne contient aucun groupe isocyanate libre.

9. Un procédé selon la revendication 7 ou 8 qui comprend l'étape initiale de mise en contact du polyisocyanate de formule (III)



dans lequel  $R^a$  est un groupe q-valent comprenant un groupe aliphatique, cycloaliphatique, hétérocyclique ou aromatique et  $q$  est un entier supérieur à 2 avec un composé contenant de l'hydrogène actif portant un groupe hydrophile qui est  $-(CH_2CH_2O)_p-$  dans lequel  $p$  est 3 ou plus ou un groupe acide carboxylique ou un dérivé de celui-ci en vue de former un polyisocyanate dispersible dans l'eau de formule  $R(NCO)_m$ .

10. Une dispersion aqueuse d'au moins un polyisocyanate bloqué tel que revendiqué dans l'une quelconque des revendications 1 à 6.
11. Une composition de revêtement qui comprend une dispersion telle que revendiquée dans la revendication 10 et un composé contenant de l'hydrogène actif.
12. Une composition de revêtement selon la revendication 11 qui est une peinture.
13. Une composition de revêtement selon la revendication 11 ou 12 qui comprend un pigment ou un support de pigment, dans lequel le support de pigment est un composé contenant un hydrogène actif.
14. Composition selon l'une quelconque des revendications 11, 12 et 13, qui contient 0,5 à 2 groupes isocyanate bloqués par groupe contenant de l'hydrogène actif.
15. Une méthode de revêtement d'un substrat qui comprend les étapes consistant à appliquer la composition telle que revendiquée dans l'une quelconque des revendications 11 à 14 à un substrat et ensuite à chauffer la composition déposée afin de réticuler le revêtement.
16. Une méthode selon la revendication 15 qui comprend également une étape de chauffage du substrat enduit.
17. Une méthode selon la revendication 15 ou la revendication 16 dans laquelle la composition est appliquée par électrodeposition.